

WHAT IS CLAIMED IS:

1                   1.       A radio receiver, comprising:  
2                   an amplifier configured to receive and amplify an intermediate frequency  
3 modulated signal having in-phase and quadrature phase DC components;  
4                   an analog-to-digital converter configured to receive the amplified intermediate  
5 frequency modulated signal and convert it to a digital signal;  
6                   a demodulator operable to demodulate the digital signal; and  
7                   DC offset calibration means coupled to the demodulator operable to provide  
8 in-phase and quadrature phase DC offset correction signals to compensate for the in-phase  
9 and quadrature phase DC components at the input of the amplifier.

10                   2.       The radio receiver of claim 1, further comprising:  
11                   delay measurement means coupled to the demodulator operable to determine a  
12 delay vector characterizing the in-phase and quadrature phase DC components.

13                   3.       The radio receiver of claim 2, wherein the delay vector is used by the  
14 DC offset calibration means to provide a digital representation of the in-phase and quadrature  
15 phase DC offset correction signals.

16                   4.       The radio receiver of claim 3, further comprising:  
17                   a first digital-to-analog converter configured to receive a in-phase component  
18 of the digital representation of the in-phase DC offset correction signal for mixing with an in-  
19 phase signal and an intermediate frequency carrier signal;  
20                   a second digital-to-analog converter configured to receive a quadrature phase  
21 component of the digital representation of the quadrature phase DC offset correction signal  
22 for mixing with a quadrature signal and the intermediate frequency carrier signal; and  
23                   a summer operable to subtract the mixed quadrature phase signal and  
24 quadrature phase DC offset correction signal component from the mixed in-phase signal and  
25 in-phase DC offset correction signal to provide a DC compensated intermediate frequency  
26 modulated signal at the input of the low noise amplifier.

27                   5.       A radio receiver, comprising:  
28                   a receiving stage configured to receive a radio signal;  
29                   a first mixer stage operable to downconvert the radio frequency signal to a  
30 first intermediate frequency in-phase signal and a first intermediate quadrature phase signal;

5 first and second low pass filters configured to receive and low pass filter the  
6 first intermediate frequency in-phase and quadrature phase signals;  
7 a second mixer stage operable to upconvert the filtered first intermediate  
8 frequency in-phase and quadrature phase signals and provide a second intermediate  
9 frequency in-phase signal and a second intermediate frequency quadrature phase signal;  
10 a summer operable to subtract the second intermediate frequency quadrature  
11 phase signal from the second intermediate frequency in-phase signal to provide an integrated  
12 signal;  
13 an automatic gain control stage coupled to the summer and operable to  
14 amplify the integrated signal;  
15 an analog-to-digital converter operable to convert the amplified integrated  
16 signal to a digital signal;  
17 a demodulator operable to demodulate the digital signal; and  
18 delay measurement means for determining a delay vector from inputs of the  
19 low pass filters to an output of the demodulator.

20  
21 6. The radio receiver of claim 5, further comprising:

22 a DC offset calibrator coupled to the delay measurement means;  
23 an in-phase digital-to-analog converter coupled between the DC offset  
24 calibrator and the second mixer stage; and  
25 a quadrature phase digital-to-analog converter coupled between the DC offset  
26 calibrator and the second mixer stage,  
27 wherein the in-phase digital-to-analog converter is operable to provide an in-  
28 phase DC offset compensation signal for the automatic gain control stage and the quadrature  
29 phase digital-to-analog converter is operable to provide a quadrature phase DC offset  
30 compensation signal for the automatic gain control stage..

31 7. A method of determining a signal delay between inputs of first and  
32 second low pass filters of a dual mixer stage radio receiver and an output of the receiver's  
33 demodulator, the method comprising the steps of:

34 applying a first known voltage to an input of an in-phase mixer of the second  
35 mixer stage;  
36 applying a second known voltage to an input of a quadrature phase mixer of  
37 the second mixer stage;

8                    setting the gain of an automatic gain control stage, coupled to the second  
9 mixer stage, to a full gain; measuring first in-phase and first quadrature phase components at  
10 the output of the demodulator;  
11                    decreasing the gain of the automatic gain control stage by a predetermined  
12 amount if the value of each first component is greater than a predetermined maximum  
13 threshold value;  
14                    storing the first in-phase and quadrature phase components if the value of each  
15 component is less than the predetermined maximum threshold value;  
16                    applying the negative of the first known voltage to the input of the in-phase  
17 mixer;  
18                    applying the value of the second known voltage to the input of the quadrature  
19 phase mixer;  
20                    measuring second in-phase and second quadrature phase components at the  
21 output of the demodulator;  
22                    decreasing the gain of the automatic gain control stage by a predetermined  
23 amount if the value of each second component is greater than the predetermined maximum  
24 threshold value;  
25                    storing the second in-phase and quadrature phase components if the value of  
26 each second component is less than the predetermined maximum threshold value; and  
27                    using the first and second quadrature phase components to compute the signal  
28 delay..

1                    8.        A method of compensating for DC offset voltages present at an input  
2 of a low noise amplifier of a dual mixer stage radio receiver, the method comprising the steps  
3 of:

4                    determining a signal delay between an output of a second mixer stage of the  
5 dual mixer stage radio receiver, said signal delay characterizing in-phase and quadrature  
6 phase components of the DC offset voltage present at the input of the low noise amplifier;  
7                    using the determined signal delay to separate and define digital representations  
8 of the in-phase DC offset voltage component and the quadrature phase DC offset voltage  
9 component;  
10                    making the digital representation of each of the in-phase and quadrature phase  
11 components more positive or more negative if it is more negative or more positive than a  
12 predetermined minimum threshold or maximum threshold; and

performing the above sequence of steps a predetermined number of times to reduce the DC offset voltage at the input of the low noise amplifier.

9. A method of setting signal levels of in-phase and quadrature phase components of a radio receiver between a minimum threshold voltage and a maximum threshold voltage, the method comprising the steps of:

(a) setting the gain of an automatic gain control to a gain value at which the signal levels of the in-phase and quadrature phase components are less than or equal to the maximum threshold voltage;

(b) comparing the signal levels of the in-phase and quadrature phase components to a predetermined minimum threshold value;

(c) increasing the gain of the automatic gain control stage by a predetermined amount; and

(d) repeating steps (b) and (c) until the signal levels of the in-phase and quadrature phase components are greater than or equal to the predetermined minimum threshold value.

10. A method of compensating for DC offset voltages at inputs of in-phase and quadrature phase low pass filters of a dual mixer stage radio receiver, said method comprising the steps of:

determining a signal delay vector between the inputs of the low pass filters, said signal delay vector characterizing in-phase and quadrature phase components of DC offset voltages at the inputs of the low pass filters;

using the signal delay vector to separate and define in-phase and quadrature phase multiplication factors associated with the in-phase and quadrature phase DC offsets;

incrementally adjusting the signal level of the in-phase component to a more positive or more negative value if the in-phase multiplication factor has a negative or positive value, respectively; and

incrementally adjusting the signal value of the quadrature phase component to a more positive or more negative value if the quadrature phase multiplication factor has a negative or positive value, respectively.